SPECIALIZATION IN MANUFACTURE

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During the past quarter of a century radical changes have taken place in the principles and practice of manufacturing. Methods in vogue twenty-five years ago would not be tolerated to-day, and those which obtain to-day would not have been countenanced then. The conditions have changed to such an extent that it means practically a revolution. Text-books that were used a quarter of a century ago are now obsolete, because they teach methods and principles that are fundamentally wrong according to the lights we have to-day; they are interesting historically, but practically they are worthless.

The industrial structure may be compared to that of a tree. The organization of the industry corresponds to the roots, the common basis and development to the main stem and the special lines of manufacture, which are from time to time added as the business grows, correspond to the branches of the tree. Formerly it was the ambition of the manufacturer to add as many new branches as possible to the main stem, so that the plant might cover a larger field, and also because of the supposed advantage that in case of a temporary falling off in demand for products of one kind, the establishment might be kept occupied continuously through a balancing demand for another product. Thus the manufacturer went on, year by year, adding branch after branch to his business, until the concern which may have started in a very small way, indeed, grew to great dimensions, spreading over many lines of industry. The catalogues of such establishments sometimes cover hundreds of pages, and include a vast variety of implements or goods.

This plan undoubtedly possessed certain advantages, but it also had serious drawbacks. In the case, for example, of the manufacture of machine tools, where a great variety of machines,

such as lathes, planers, etc., are made, of different sizes and shapes to suit the wants of many customers, the result is, sometimes, the accumulation of an enormous stock of costly patterns and fixtures, which are kept in storage for years, perhaps without duplicate orders therefor, and these are finally destroyed to make room for other similar but newer accumulations. When a single new machine is ordered, it is customary to make duplicates of many of the parts. These duplicates are carried in stock for future use, sometimes for years, until, in fact, the design becomes obsolete, and then the patterns, fixtures and duplicate parts, which represent a large original investment of money and a continual expense for interest, storage, insurance, etc., are condemned to the scrap heap. Until this time arrives these patterns, castings, duplicate parts, etc., appear as "assets" on the books of the concern, often at a false value, for the annual allowance made for "depreciation" does not cover the ultimate loss due to obsolete fixtures and machines.

Partly as the result of experiences of this nature, specialization in manufacturing has become a prominent feature in recent years, resulting in an astonishing decrease in cost and increase in production. Specialization in manufacture means that the manufacturer selects some article or product for which there is a heavy or a constant demand, and through devoting his entire capital, energy and ability to its development and the betterment of the methods or appliances of its manufacture so reduces his costs on it as to be in at least partial control of the trade. A few illustrations, taken from actual experience, of the advantage of quantity manufacture and undivided attention will be in point.

First. To show the difference in cost where the same machinery and appliances are used, but the quantity is increased. In making two oil pumps for hammer cylinders the cost is $20.19 each; the same pumps in lots of twelve cost $6.12 each, a reduction of 69 per cent., due largely to the increased quantity, and this reduction could be substantially increased if the quantity should be further increased.

Second. To show the difference in cost where different machinery or improved processes are used.

For making one hundred ¾ inch by 4 inch hexagonal head finished bolts, on a modern turret lathe, by reducing the body of the bolt from a commercial bar of hexagonal steel of a size required for

the head, the cost is $15.84. Similar bolts are now made by a machine-screw company by welding electrically the head (cut from a bar of hexagonal steel) to the body of the bolt, made from a piece of cold rolled steel the exact diameter of the bolt, and sold for $5.88, which shows a saving in favor of this process of approximately 63 per cent.

Third. Where an entirely new process is used. The instance taken is that of the manufacture of cores for molds, where the specialization developed a new process or made it advantageous to apply it. Certain cores which formerly cost $1.18 each, now cost 30 cents each. Others which formerly cost 56 cents each, now cost 14 cents each; others which formerly cost $6 each, now cost 90 cents each, and so on.

When Edison first made the small incandescent electric lamps, consisting of a carbon filament fixed by platinum wires in a pear-shaped glass bulb, from which the air had been exhausted, the cost was $3 each; now there are many million similar lamps of better quality made each year and sold at less than 20 cents each. Formerly watches were made by hand and were costly luxuries; now they are made by machinery in lots of a thousand at a time, and the cost of a new watch, that will keep fairly good time, is less than the cost of having an expensive watch cleaned. The same principles apply in all lines of manufacture, and it has been found that reduction in cost of production, due to specialization in manufacture, is naturally followed by increased demand, for the simple reason that each successive reduction brings a new class of consumers or purchasers into the market, and a commodity which was regarded as a luxury of the few when the cost was relatively high, becomes a necessity of the many when the cost is reduced to a sufficiently low level. When the cost has descended to the point which is necessary to establish this condition, the demand for the commodity becomes permanent, subject to occasional temporary fluctuations following variations in the general prosperity of a community or the passing of the fad if it be one.

There are, of course, dangers of overproduction in this modern system of specialization, of which we have had many evidences of late, but it seems to be pretty well recognized that the secret of success in manufacturing lies largely in concentration of effort, in developing the plant to the highest degree, so that a superior product may be turned out at a minimum cost.

This implies a complete modern equipment of machinery and modern methods of management. Formerly old tools were venerated; now they are ruthlessly cast away as soon as superior machines can be obtained.

Not long ago a well-known English manufacturer visited this country to inspect our methods, and on his return he was asked "What is the secret of America's success in manufacturing?" His reply was the single word "scrapping," by which he meant that all appliances were considered obsolete in this country and condemned as soon as new improvements were found. It may be stated as a general proposition that if a new machine be invented which will, by increasing the output only 10 per cent., reduce the cost an equal amount, it pays to scrap the old machine. In many instances improvements have been made which have reduced the cost of manufacture over 50 per cent., and herein lies also one of the dangers of specialization in manufacture.

An establishment may have its capital tied up in a complete outfit of machinery designed to produce one article at the lowest cost, for which there may be a constant demand at a remunerative price. Then an ingenious inventor may design a new machine, or devise a new method of manufacture, which will, perhaps, produce better goods at far lower cost, and the utility of the old plant is at once destroyed. Its costly machinery may be of little or no value for any other purpose, and so a hitherto profitable industry may be wiped out of existence at one fell stroke. This is not an imaginary statement, but it can be supported by numerous facts.

In England, several years ago, a clever young chemist devised a new method of producing aluminum, using sodium as an intermediary agent, the cost of aluminum being less than half that of reduction by methods then in vogue. A magnificent plant was erected, requiring an investment of several hundred thousand dollars. Before the manufacturing operations were fairly under way an American electrolytic process was brought out, doing away with the intermediary element and reducing the cost to a mere fraction of that by the sodium method. The English process was at once abandoned.

A few years ago a new method of treating steel for cutting tools was devised, which enabled the tools to cut steel and iron four or five times as rapidly as could be done with any steel tools made

up to that time. Shop rights were sold at large figures, and furnaces and other necessary appliances installed in several establishments for treating cutting tools according to this process. In a very short time new alloys were discovered, of which cutting tools are now made, having the same capacity without this costly treatment, and so the value of the process has been largely effaced.

The element of time was far less considered formerly than now, because it was of far less value. When wages were low and handwork in vogue, the ratio between the value of materials and of time was the reverse of what it is now, when in many manufactures the time cost exceeds all other costs. It is said that when a carpenter drops a wire nail, it is false economy to take the time to pick it up instead of using another.

The standardization of parts now so general, is at once a cause and a result of specialization in manufacture. While some large manufacturers make most of their parts in their own factory, few make all, and a large proportion buy many and some buy practically all. Many makers of parts confine their manufacture to a single one. The more recent the development of a mechanical invention, the more this practice seems to be adopted. Thus in the manufacture of automobiles the technical papers are filled with advertisements of parts; one company makes only gasoline engines, another frames, another mufflers, another radiators, another bodies, and so on. As was the case in the bicycle era, so now many of the cheaper class of automobiles are composed of "parts," purchased where they can be bought wholesale at a low rate, and "assembled" by the so-called manufacturer.

Certain fundamental principles characterize American methods of manufacture; such as the employment of special machines to perform specific operations only, whereby the output of a factory is enormously increased, minute and systematized division of labor effected, the costly work of finishing and adjusting minimized, and the highest development of skill, accuracy and dispatch acquired. The high wages paid to skilled labor in this country have acted as a stimulus to the invention and perfecting of labor-saving machinery, and the employment of such labor-saving machinery operated by high-priced, intelligent mechanics has resulted sometimes in a very much larger output and lower cost of product per man employed than anywhere in the world under old conditions. These features have perhaps

received most notable development in the fine art of watchmaking by machinery in America, wherein the acme of perfection and economy is shown.

The system of concentration of labor in large factories for making watches in this country is the antithesis of the method of scattered manufacturing which prevailed for centuries in Europe, notably in Switzerland. M. Favre-Peret, who investigated this industry in the New England States some years ago, stated that the average production of 40,000 workmen in Switzerland was 40 watches each per annum, while in America the average was 150 fine watches for each man employed.

By the aid of special machines in these watch factories, one man can make 1,200 fine screws per day, some of which are so small that more than 100,000 are required to weigh a pound. One of the finest pieces made is a "pallet-arbor" or pivotal bolt, which, for a small-sized watch, has a thread of 260 to the inch, weighs $^1/_{180000}$ of a pound, undergoes 25 operations and costs but 2¼ cents. Measurements are gauged to $^1/_{25000}$ of an inch.

The balance wheel, after being machined, weighs only 7 grains, and when fitted with 16 gold screws weighs 7.2 grains; there are 80 separate operations upon a balance wheel, 66 of them being drilling, threading and countersinking holes; the drills revolve at a speed of 4,800 turns a minute, and one operator can drill upwards of 2,200 holes for the balance wheels per day. A full and complete report upon this highly specialized manufacture of watches in this country may be found in Volume II of the "Tenth Census of the United States."

A few years ago M. Levasseur, a member of the French Institute, an authority on industrial economics, made a careful study of industrial conditions in the United States, and referred in his report thereon to the prodigious proportions which the tendency of modern industry towards specialization has assumed in this country. He described in detail the development of the shoe industry in Massachusetts to illustrate this evolution. Until 1850 shoes were for the most part made in the Bay State by farmers working at home at seasons when farm work was slack. Little by little manufactories were established, until now everything is done by machines which are marvelous in their variety and rapidity of production. Here specialization has been developed to the highest degree. One factory employing 233 hands produced 2,100 pairs of shoes a day.

A delegation of French workmen, after visiting our industrial establishments, said, in their report, that "The manufacturers are unceasingly replacing old machinery by improved types. Although the McCormick Reaper Works are the oldest of the kind in the United States, we did not find there a single machine out of date. As soon as a machine can be replaced by one giving better results, a manufacturer does not hesitate to send it to the junk shop." The delegates concluded their report with these words: "The rapidity of the machines is astonishing, and the development of specialization seems sometimes to border on the marvelous."

In all lines of manufacture in the United States the same tendency towards specialization is apparent, and it is a question for serious consideration whether this process may not be carried too far, resulting in the future in a variety of unlooked-for evils. Not the least of these perhaps is the decline of the "all-round skilled mechanic." Young men who enter our shops to-day find employment in tending special machines and soon become highly trained in their operation, so that they earn large wages, consequent, of course, upon their ability to turn out, by the aid of these machines, the maximum amount of work with minimum of defects. They are encouraged by their employers to continue at one job and feel little ambition to change to another class of work, or to another kind of machine, where their experience avails but little. Thus we have skilled planer hands, who know nothing about the operation of lathes, milling machines or other mechanical appliances in the same shops.

The Baldwin Locomotive Works, the largest of the kind in the world, and the most highly developed in specialization of manufacture, have already experienced the difficulty of finding young men competent to take the place of older hands, and have shown wise forethought in establishing a new school of apprentices, with a general superintendent in charge and a staff of supervisors or foremen of apprentices. There are at present three classes of apprentices, numbering in all between four and five hundred in these works. The apprentices are not kept for an indefinite time in any one department, but are moved from one to another as they advance in experience, so that when they have served their full terms they graduate not as skilled "planer hands" or "lathe operators" merely, but as skilled mechanics. Furthermore, this system develops a feel-

ing of proper ambition in the young man and of attachment to his alma mater. This is, in effect, an industrial college for the poor boy, worthy of emulation by other manufacturing establishments; the mutual benefit to employer and employee will be felt in the years to come, and will continue to increase in value to all concerned.

The tendency toward specialization is not confined to manufactures. In the foregoing the attempt has been made to tell of and to illustrate its influence and effects in this line. The tendency seems to extend to engineering, medicine and the other professions, indeed, to pervade every field of human endeavor. It is an evolution amounting to revolution of methods of doing the world's work.